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EXAMINER

CHEN, KIN CHAN

ART UNIT PAPER NUMBER

1765

DATE MAILED: 06/21/2004

Please find below and/or attached an Office communication concerning this application or proceeding.

# Office Action Summary

Application No.

09/820,692

Applicant(s)

CH IEN ET AL.

Examiner

Kin-Chan Chen

Art Unit

1765

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

## Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

## Status

- 1) ☒ Responsive to communication(s) filed on 26 April 2004.
- 2a) ☐ This action is **FINAL**. 2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

## Disposition of Claims

- 4) ☒ Claim(s) 1-4, 6-12 and 14-25 is/are pending in the application.
- 4a) Of the above claim(s) \_\_\_\_\_ is/are withdrawn from consideration.
- 5) ☐ Claim(s) \_\_\_\_\_ is/are allowed.
- 6) ☒ Claim(s) 1-4, 6-12 and 14-23 is/are rejected.
- 7) ☒ Claim(s) 24 and 25 is/are objected to.
- 8) ☐ Claim(s) \_\_\_\_\_ are subject to restriction and/or election requirement.

## Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on \_\_\_\_\_ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.  
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).  
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

## Priority under 35 U.S.C. § 119

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All b) ☐ Some \* c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
2. ☐ Certified copies of the priority documents have been received in Application No. \_\_\_\_\_.
3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).
- \* See the attached detailed Office action for a list of the certified copies not received.

## Attachment(s)

- 1) ☒ Notice of References Cited (PTO-892)
- 2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
- 3) ☐ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08)  
Paper No(s)/Mail Date \_\_\_\_\_
- 4) ☐ Interview Summary (PTO-413)  
Paper No(s)/Mail Date \_\_\_\_\_
- 5) ☐ Notice of Informal Patent Application (PTO-152)
- 6) ☐ Other: \_\_\_\_\_

## DETAILED ACTION

### *Claim Rejections - 35 USC § 103*

1. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

2. Claims 1-4, 6-12, and 14-23 are rejected under 35 U.S.C. 103(a) as being unpatentable over Hung et al. (US 6,174,451) in view of Wang et al. (US 6,074,959) and Schmitt (US 6,228,438) as evidenced by Hubacek (US 6,451,157).

Hung teaches a method of etching a dielectric layer (e.g., oxide layer) with selectivity to an underlying stop layer. A semiconductor substrate is supported in a plasma etch reactor. The substrate includes a dielectric layer (e.g., oxide layer) over a nitride stop layer (col. 2, lines 24-31; Figs 1 and 2), e.g., SAC structure. An etchant gas may be supplied to the plasma etch chamber. Etching openings may be performed in the dielectric layer (Fig. 1) by energizing the etchant gas into a plasma state. The etchant gas may comprise a hydrogen-free fluorocarbon gas represented by  $C_xF_y$  gas wherein  $y/x < 1.5$  (such as  $C_4F_6$ ) and carrier gas (such as Ar). See col. 7, TABLE 1, first etch recipe and col. 7, lines 33-56. The main etch (using  $C_4F_6$ ) with no  $CH_2F_2$  may be used to etch **the entire oxide layer** (col.10, lines 21-24).

Unlike the claimed invention, Hung does not teach that an oxygen-containing gas may be incorporated in the etchant gas for oxide layer ( dielectric layer) etching. In a

Art Unit: 1765

method of plasma etching openings of dielectric layer with high selectivity of dielectric to the silicon nitride, Wang teaches that fluorocarbon may be used (Fig 1; col. 9, lines 42-47). The process may be modified by the addition of carbon monoxide, nitrogen, or oxygen, all of which are known to enhance selectivity and increase the etch stop margin (col. 10, lines 23-26). Hence, it would have been obvious to one with ordinary skill in the art to modify the etchant gas of Hung by adding oxygen as taught by Wang because Wang teaches that to do so will enhance selectivity and increase the etch stop margin. Hung teaches that his oxide etching process (with nitride stop layer) may use commercially available plasma reactors (col. 11, lines 43-44). Therefore, it would have been obvious to one with ordinary skill in the art to use popular commercial available plasma reactors. Schmitt is relied on only to teach one of the popular commercial available plasma reactors with dual frequency capacitively coupled plasma reactor including an upper showerhead electrode and a bottom electrode as claimed (see col. 1, line 15-17; col. 8, lines 1-12). Hence, it would have been obvious to one with ordinary skill in the art to use the popular commercial available plasma reactors as disclosed by Schmitt in the process of Hung and Wang in order to provide their art recognized advantages and produce an expected result. Also see Hubacek (US 6,451,157) in the record to show that the showerhead arrangement can be used in any type of semiconductor processing apparatus. Furthermore, The apparatus limitations do not have weight in process claim, unless they affect the process in a manipulative sense.

***In re Tarzy-Hornock*, 158 USPQ 141. Or *Ex parte Pfieffer* 135 USPQ 31**

As to dependent claim 3, Hung teaches that the stop layer may be silicon nitride and the etch rate selectivity of the dielectric to the silicon nitride is at least 10 (col. 7, lines 50-56).

As to dependent claim 4, Hung teaches doped or undoped silicon oxide layer (col. 1, lines 27-33).

As to dependent claim 9, 10, 16, and 17, the combined prior art (Hung and Wang) teaches  $C_xF_y$  gas (such as  $C_4F_6$ ) and oxygen. Hung and Wang are relied on for the same reasons as stated, supra. The combined prior art does not teach the ratio of flow rates of the said fluorocarbon to oxygen. The instant claims differ from the prior art by teaching the ratio of flow rates of the said fluorocarbon to oxygen (such as 0.5:1 to 5:1 in claims 9 and 16; 1:1 to 2:1 in claims 10 and 17). However, same is known to be result-effective variable, it would have been obvious to one of ordinary skilled in the art to determine the suitable ratio of flow rates through routine experimentation in the combined prior art in order to produce the best etched product achievable.

As to dependent claim 11, Hung (col. 8, Table 2, main etch) teaches that pressure in the plasma etch reactor may be 10 mTorr and temperature of the substrate support (e.g., cathode temperature) may be 15 °C, which is within the claimed range.

Dependent claim 12 differs from the combined prior art by specifying the different process parameters (such as pressure of reactor and temperature of the substrate support). However, Hung teaches that the process parameters may vary and dependent on different commercially available plasma reactors (col. 11, lines 43-44). Furthermore, same were known to be result-effective variables, it would have been

obvious to one of ordinary skilled in the art to determine the optimum, operable range of process parameters (e.g., pressure of reactor and temperature of the substrate support) for different commercially available plasma reactors in the combined prior art in order to provide their art recognized advantages and produce an expected result.

As to dependent claim 14, Wang teaches that fluorocarbon may be used (Fig 1; col. 9, lines 42-47). The process may be modified by the addition of carbon monoxide (CO), which is known to enhance selectivity and increase the etch stop margin (col. 10, lines 23-26). Hence, it would have been obvious to one with ordinary skill in the art to modify the etchant gas of Hung by adding carbon monoxide as taught by Wang because Wang teaches that to do so will enhance selectivity and increase the etch stop margin. The combined prior art does not teach that the rate of 50 to 500 sccm CO may be supplied to the etch reactor. However, same is known to be result-effective variable, it would have been obvious to one of ordinary skilled in the art to determine the suitable ratio through routine experimentation in the combined prior art in order to produce the best etched product achievable.

As to dependent claim 15, Hung teaches  $C_4F_6$  (col. 7, line 4).

As to dependent claim 18, in order to complete the etching of the openings, keeping an amount of etchants (e.g.,  $C_4F_6$  and oxygen) sufficient to avoid etch stop is considered inherent in the method of combined Hung and Wang. Hung and Wang are relied on for the same reasons as stated, *supra*.

As to dependent claims 19-21, Hung teaches that the dielectric layer (oxide layer) may be BPSG (col. 1, lines 32-34) and the stop layer may comprise silicon nitride

(col. 2, lines 29-30). The etch rate selectivity of the oxide layer (e.g., TEOS) to the corner portion of the silicon nitride may be 20 (col. 7, lines 51-56). The combined prior art (Hung and Wang) teaches  $C_xF_y$  gas (such as  $C_4F_6$ ) and oxygen. Hung and Wang are relied on for the same reasons as stated, supra. The combined prior art does not teach the etch rate selectivity of the BPSG (or dielectric) to nitride (or stop layer) and the ratio of the flow rates of  $O_2 : C_4F_6$ . The instant claims differ from the prior art in the etch rate selectivity of the BPSG (or dielectric) to nitride (or the stop layer) ( e.g., at least 15 in claim 19; greater than 30:1 in claim 21) and the flow rates having a ratio of  $O_2 : C_4F_6$  (e.g., 0.5 to 1.2 in claim 20). However, the ratio of the flow rates of  $O_2$  : fluorocarbon is known to be result-effective variable, it would have been obvious to one of ordinary skilled in the art to determine the suitable flow rate ratio of  $O_2$  to  $C_4F_6$  through routine experimentation in the combined prior art in order to produce the best etched product achievable and desired etch rate selectivity.

As to dependent claims 22-23, Hung teaches that the main etch with no  $CH_2F_2$  may be used to etch **the entire oxide layer** (col.10, lines 21-24), and it appears that the etchant for etching the entire oxide layer is hydrogen-free.

As to dependent claims 7 and 8, Hung (col. 7, TABLE I, first etch recipe) teaches that the flow rates of 20 sccm  $C_4F_6$  and 100 sccm Ar may be used, which is within the claimed range. Hung, Wang and Schmitt are relied on for the same reasons as stated, supra. The combined prior does not disclose the flow rate of oxygen ( $O_2$ ) for the process. However, same is known to be result-effective variable, it would have been obvious to one of ordinary skilled in the art to determine the suitable flow rate of oxygen

(O<sub>2</sub>) for the process through routine experimentation in the combined prior art in order to produce the best-etched product achievable.

The combined prior art does not disclose the range of RF energy being supplied into the process. The instant claim (e.g., claim 2) differs from the combined prior art by specifying showerhead electrode and bottom electrode being supplied 0 to 3000 watts of RF energy. However, it is merely a matter of choice of engineering depending on product requirement. One skilled in the art at the time of the invention would have found it obvious to apply engineering practice to determine the range of RF energy suitable for the process and the specific product requirement in order to provide their art recognized advantages and produce the best-etched product achievable. It is noted that applicant did not traverse the aforementioned conventionality of features, which have been stated in the office action in Paper No.7.

3. Claims 1-4, 6-12, and 14-23 are rejected under 35 U.S.C. 103(a) as being unpatentable over Kadomura (US 5,366,590) in view of Wang et al. (US 6,074,959) and Schmitt (US 6,228,438) as evidenced by Hubacek (US 6,451,157).

Kadomura teaches a method of etching a dielectric layer) with selectivity to an underlying stop layer. A semiconductor substrate is supported in a plasma etch reactor. The substrate includes a dielectric layer (e.g., oxide layer) over a nitride stop layer. An etchant gas may be supplied to the plasma etch chamber. Etching openings may be performed in the dielectric layer by energizing the etchant gas into a plasma state. The etchant gas may comprise a hydrogen-free fluorocarbon gas represented by C<sub>x</sub>F<sub>y</sub> gas



wherein  $y/x < 1.5$  (such as  $C_4F_6$  or  $C_6F_6$ ). See col. 4, lines 4-42 and col. 5 line 60 through col. 6, lines 46. Kadomura teaches that his oxide etching process (with nitride stop layer) may use commercially available plasma reactors. Therefore, it would have been obvious to one with ordinary skill in the art to use popular commercial available plasma reactors. Schmitt is relied on only to teach one of the popular commercial available plasma reactors with dual frequency capacitively coupled plasma reactor including an upper showerhead electrode and a bottom electrode as claimed (see col. 1, line 15-17; col. 8, lines 1-12). Hence, it would have been obvious to one with ordinary skill in the art to use the popular commercial available plasma reactors as disclosed by Schmitt in the process of Kadomura and Wang in order to provide their art recognized advantages and produce an expected result. Also see Hubacek (US 6,451,157) in the record to show that the showerhead arrangement can be used in any type of semiconductor processing apparatus.

Unlike the claimed invention, Kadomura does not teach that an oxygen-containing gas may be incorporated in the etchant gas for oxide layer ( dielectric layer) etching. In a method of plasma etching openings of dielectric layer with high selectivity of dielectric to the silicon nitride, Wang teaches that fluorocarbon may be used (Fig 1; col. 9, lines 42-47). The process may be modified by the addition of carbon monoxide, nitrogen, or oxygen, all of which are known to enhance selectivity and increase the etch stop margin (col. 10, lines 23-26). Hence, it would have been obvious to one with ordinary skill in the art to modify the etchant gas of Kadomura by adding oxygen as

taught by Wang because Wang teaches that to do so will enhance selectivity and increase the etch stop margin.

As to dependent claim 9, 10, 16, and 17, the combined prior art (Kadomura and Wang) teaches  $C_xF_y$  gas and oxygen. Kadomura and Wang are relied on for the same reasons as stated, *supra*. The combined prior art does not teach the ratio of flow rates of the said fluorocarbon to oxygen. The instant claims differ from the prior art by teaching the ratio of flow rates of the said fluorocarbon to oxygen (such as 0.5:1 to 5:1 in claims 9 and 16; 1:1 to 2:1 in claims 10 and 17). However, same is known to be result-effective variable, it would have been obvious to one of ordinary skilled in the art to determine the suitable ratio of flow rates through routine experimentation in the combined prior art in order to produce the best etched product achievable.

Dependent claims 11 and 12 differ from the combined prior art by specifying the different process parameters (such as pressure of reactor and temperature of the substrate support). However, same were known to be result-effective variables, it would have been obvious to one of ordinary skilled in the art to determine the optimum, operable range of process parameters (e.g., pressure of reactor and temperature of the substrate support) for different commercially available plasma reactors in the combined prior art in order to provide their art recognized advantages and produce an expected result.

As to dependent claim 14, Wang teaches that fluorocarbon may be used (Fig 1; col. 9, lines 42-47). The process may be modified by the addition of carbon monoxide (CO), which is known to enhance selectivity and increase the etch stop margin (col. 10,

lines 23-26). Hence, it would have been obvious to one with ordinary skill in the art to modify the etchant gas of Kadomura by adding carbon monoxide as taught by Wang because Wang teaches that to do so will enhance selectivity and increase the etch stop margin. The combined prior art does not teach that the rate of 50 to 500 sccm CO may be supplied to the etch reactor. However, same is known to be result-effective variable, it would have been obvious to one of ordinary skilled in the art to determine the suitable ratio through routine experimentation in the combined prior art in order to produce the best etched product achievable.

As to dependent claim 18, in order to complete the etching of the openings, keeping an amount of etchants sufficient to avoid etch stop is considered inherent in the method of combined Kadomura and Wang. Kadomura and Wang are relied on for the same reasons as stated, *supra*.

As to dependent claims 19-21, It is well known in the art of semiconductor device fabrication that the dielectric layer (oxide layer) may be BPSG or silicon dioxide and etching characteristics are equivalent, the substitution of one for the other would have expected to provide similar result. The combined prior art teaches  $C_xF_y$  gas (such as  $C_4F_6$  or  $C_4F_8$ ) and oxygen. Kadomura and Wang are relied on for the same reasons as stated, *supra*. The combined prior art does not teach the etch rate selectivity of the BPSG (or dielectric) to nitride (or stop layer) and the ratio of the flow rates of  $O_2 : C_4F_6$ . The instant claims differ from the prior art in the etch rate selectivity of the BPSG (or dielectric) to nitride (or the stop layer) ( e.g., at least 15 in claim 19; greater than 30:1 in claim 21) and the flow rates having a ratio of  $O_2 : C_4F_6$  (e.g., 0.5 to 1.2 in claim 20).

Art Unit: 1765

However, the ratio of the flow rates of  $O_2$  : fluorocarbon is known to be result-effective variable, it would have been obvious to one of ordinary skilled in the art to determine the suitable flow rate ratio of  $O_2$  to  $C_4F_6$  through routine experimentation in the combined prior art in order to produce the best etched product achievable and desired etch rate selectivity.

The combined prior does not disclose the flow rate of oxygen ( $O_2$ ) for the process. However, same is known to be result-effective variable, it would have been obvious to one of ordinary skilled in the art to determine the suitable flow rate of oxygen ( $O_2$ ) for the process through routine experimentation in the combined prior art in order to produce the best-etched product achievable.

The combined prior art does not disclose the range of RF energy being supplied into the process. The instant claim (e.g., claim 2) differs from the combined prior art by specifying showerhead electrode and bottom electrode being supplied 0 to 3000 watts of RF energy. However, it is merely a matter of choice of engineering depending on product requirement. One skilled in the art at the time of the invention would have found it obvious to apply engineering practice to determine the range of RF energy suitable for the process and the specific product requirement in order to provide their art recognized advantages and produce the best-etched product achievable.

***Allowable Subject Matter***

4. Claims 24 and 25 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

***Response to Arguments***

5. Applicant's arguments filed on April 26, 2004 have been fully considered but they are not persuasive.

Applicant has argued that the addition of oxygen was not known from the teachings of Wang. It is not persuasive. As has been stated in the office action, Wang teaches that the addition of carbon monoxide, nitrogen, or oxygen, all of which are known to enhance selectivity and increase the etch stop margin (col. 10, lines 23-26). Hence, it would have been obvious to one with ordinary skill in the art to modify the etchant gas of Hung by adding oxygen as taught by Wang because Wang teaches that to do so will enhance selectivity and increase the etch stop margin.

Applicant has argued that the Schmitt system is not suitable for Hung's process. It is not persuasive. As has been stated in the office action, it would have been obvious to one with ordinary skill in the art to use the popular commercial available plasma reactors as disclosed by Schmitt in the process of Hung and Wang in order to provide their art recognized advantages and produce an expected result. Also Hubacek (US

6,451,157) in the record to show that the showerhead arrangement can be used in any type of semiconductor processing apparatus. Furthermore, The apparatus limitations do not have weight in process claim, unless they affect the process in a manipulative sense. See the case law cited.

### ***Conclusion***

6. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure. Hubacek (US 6,451,157; col. 4, lines 39-44) discloses that the showerhead arrangement can be used in any type of semiconductor processing apparatus.

7. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Kin-Chan Chen whose telephone number is (571) 272-1461. If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Nadine Norton can be reached on (571) 272-1465. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306. Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you

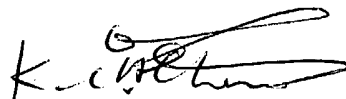
Application/Control Number: 09/820,692

Page 14

Art Unit: 1765

have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

June 15, 2004

A handwritten signature in black ink, appearing to read 'Kin-Chan Chen', with a stylized flourish at the end.

Kin-Chan Chen  
Primary Examiner  
Art Unit 1765

K-C C